Circular polarized light for the photoemission branch at Beamline 12

Who wants it?

U. Of Colorado — Dessau
Stanford U. — Shen
UC Berkeley — Lanzara

Why?

RAPID COMMUNICATIONS

PHYSICAL REVIEW B VOLUME 61, NUMBER 6 1 FEBRUARY 2000-II

Proposal for an experiment to test a theory of high-temperature superconductors

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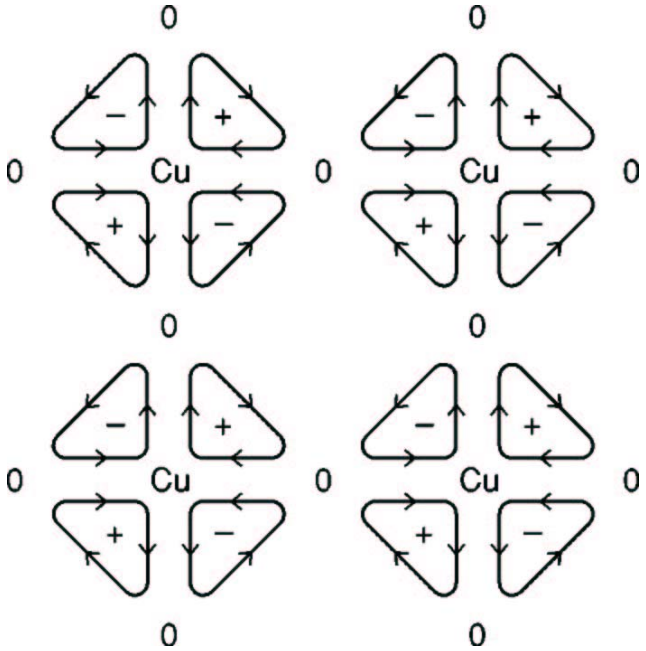
(Received 21 October 1999)

A theory for the phenomena observed in copper-oxide based high-temperature superconducting materials derives an elusive time-reversal and rotational symmetry-breaking order parameter for the observed pseudogap phase ending at a quantum-critical point near the composition for the highest T_c. An experiment is proposed to observe such a symmetry breaking. It is shown that angle-resolved photoemission yields a current density which is different for left and right circularly polarized photons. The magnitude of the effect and its momentum dependence is estimated. Barring the presence of domains of the predicted phase, an asymmetry of about 0.1 is predicted at low temperatures in moderately underdoped samples.



Argonne group says YES!

Spontaneous breaking of time-reversal symmetry in the pseudogap state of a high-T_c superconductor

A. Kaminski*†, S. Rosenkranz*†, H. M. Fretwell‡, J. C. Campuzano*†, Z. Li§, H. Raffy§, W. G. Cullen†, H. You†, C. G. Olson||, C. M. Varma¶ & H. Höchst#

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† *Materials Science Division, Argonne National Laboratory, Argonne, Illinois 60439, USA*
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¶ *Bell Laboratories, Lucent Technologies, Murray Hill, New Jersey 07974, USA*
# *Synchrotron Radiation Center, Stoughton, Wisconsin 53589, USA*

A change in 'symmetry' is often observed when matter undergoes a phase transition—the symmetry is said to be spontaneously broken. The transition made by underdoped high-transition-temperature (high-T_c) superconductors is unusual, in that it is not a mean-field transition as seen in other superconductors. Rather, there is a region in the phase diagram above the superconducting transition temperature T_c (where phase coherence and superconductivity begin) but below a characteristic temperature T^* where a 'pseudogap' appears in the spectrum of electronic excitations[1,2]. It is therefore important to establish if

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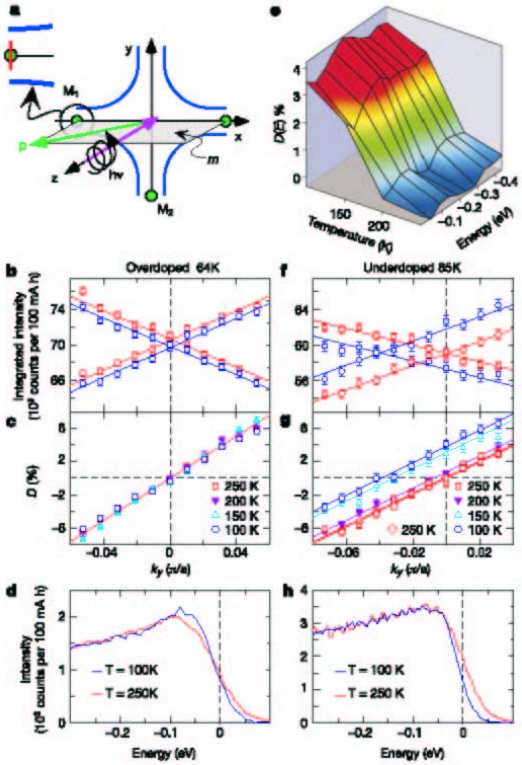
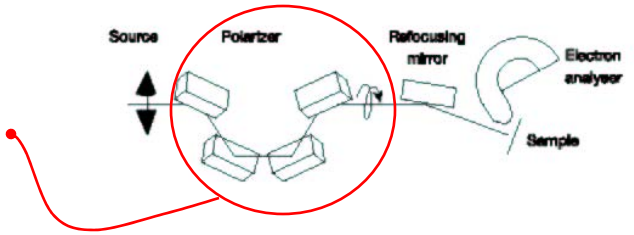
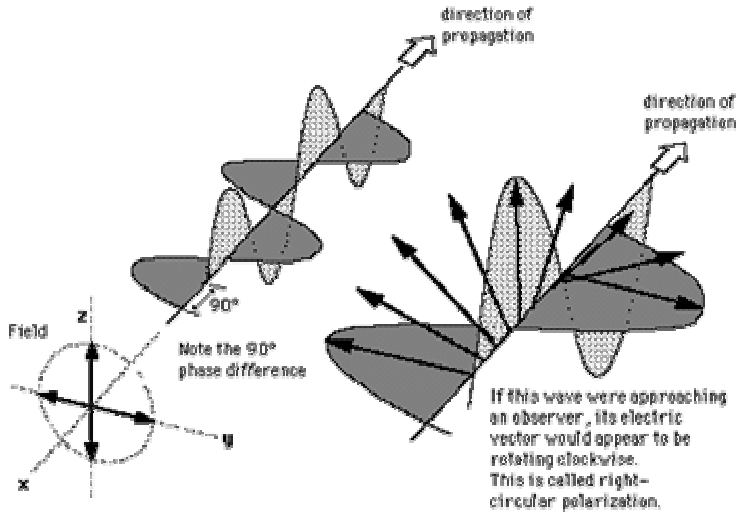
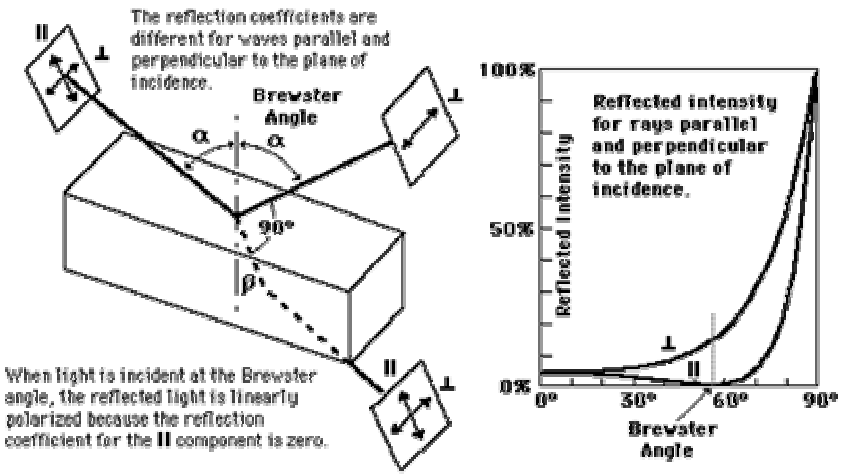


Device which made this study possible:
Quadruple reflection circular polarizer




direction of propagation
direction of propagation
90°
Field
z
y
x
Note the 90° phase difference
If this wave were approaching an observer, its electric vector would appear to be rotating clockwise.
This is called right-circular polarization.


The reflection coefficients are different for waves parallel and perpendicular to the plane of incidence.
Brewster Angle
α
α
90°
β
When light is incident at the Brewster angle, the reflected light is linearly polarized because the reflection coefficient for the II component is zero.
100%
50%
0%
Reflected intensity
Reflected intensity for rays parallel and perpendicular to the plane of incidence.
0°
30°
60°
90°
Brewster Angle

Polarizer is on sale at Physical Science Laboratories, U. of Wisconsin-Madison

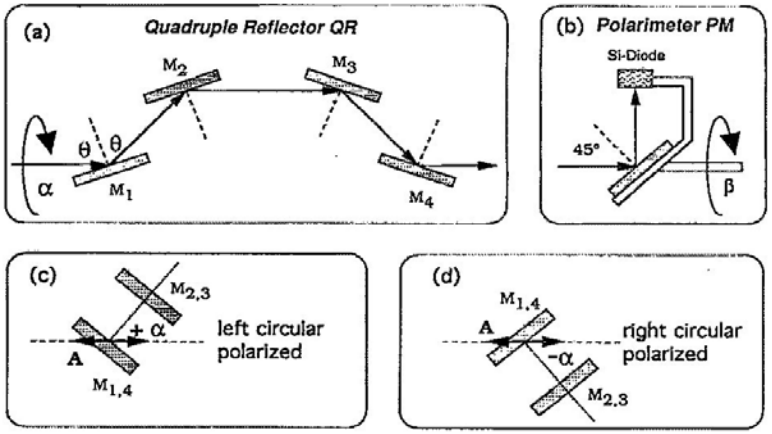


FIG. 1. (a) Schematic of the QR layout. (b) Schematic of the 45°-PM layout. (c) and (d) QR orientation for LCP and RCP.

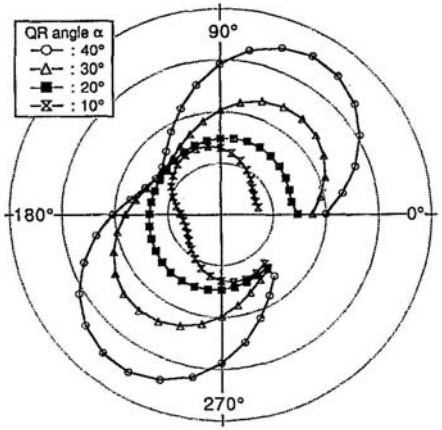


FIG. 4. Intensity measurements with the 45° PM for different angles of rotation α of the QR. The angle of incidence was θ=78° and the photon energy was $h\nu$=25 eV.

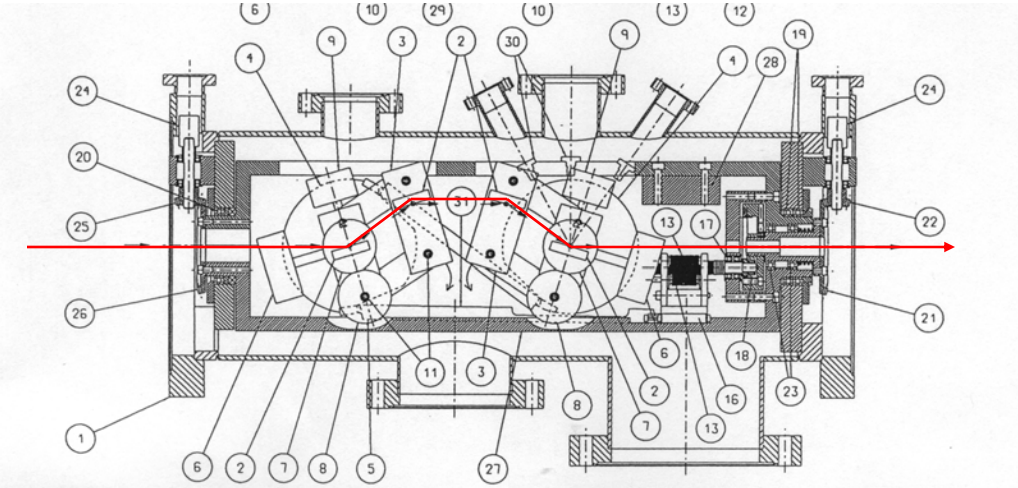


Fig. 7. (a) Top view of the mechanical layout of the quadruple reflector housing mechanism. (b) Side view of the polarizer

NSLS has bought and commissioned one for U5 / spin-polarized ARPES /

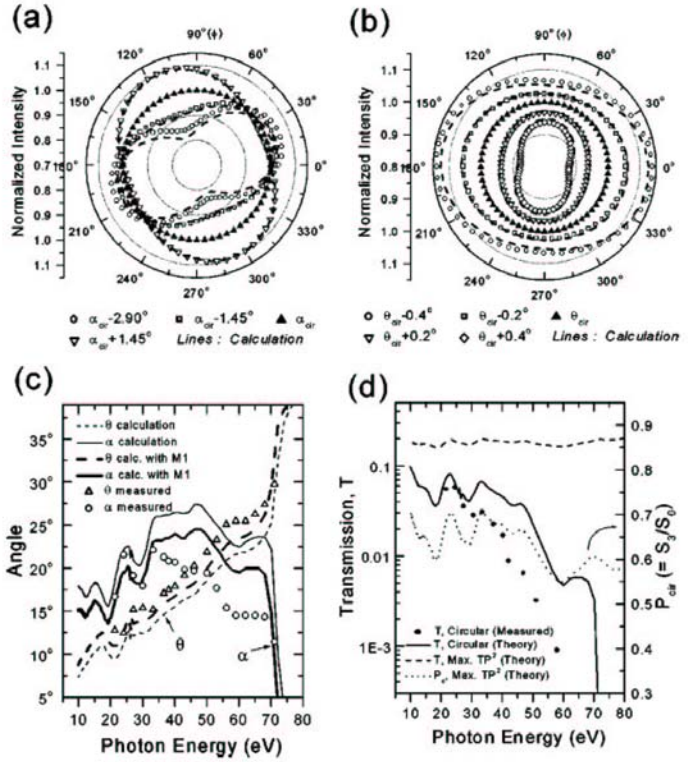


FIG. 2. (a) and (b) Measured (symbols) and calculated (lines) analyzer photodiode intensities as a funtion of φ-angle with slight changes of α-, θ-angles from pure CPL, $(\alpha,\theta)^{cir}$, at photon energy 40 eV. (c) Measured (symbols) and calculated (lines) α-, θ- angles for $(\alpha,\theta)^{cir}$ as a function of photon energy. (d) Measured (dots) and calculated (solid line) transmission at pure circular polarization condition, calculated transmission (dashed line) and degree of circular polarization P_{cir} (dotted line) at maximum TP^2_{cir} condition of the QR polarizer as a function of photon energy.

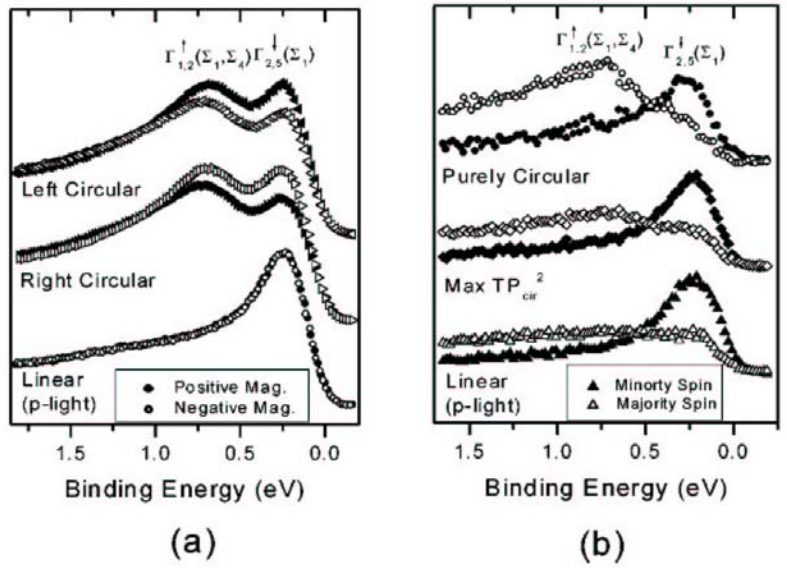
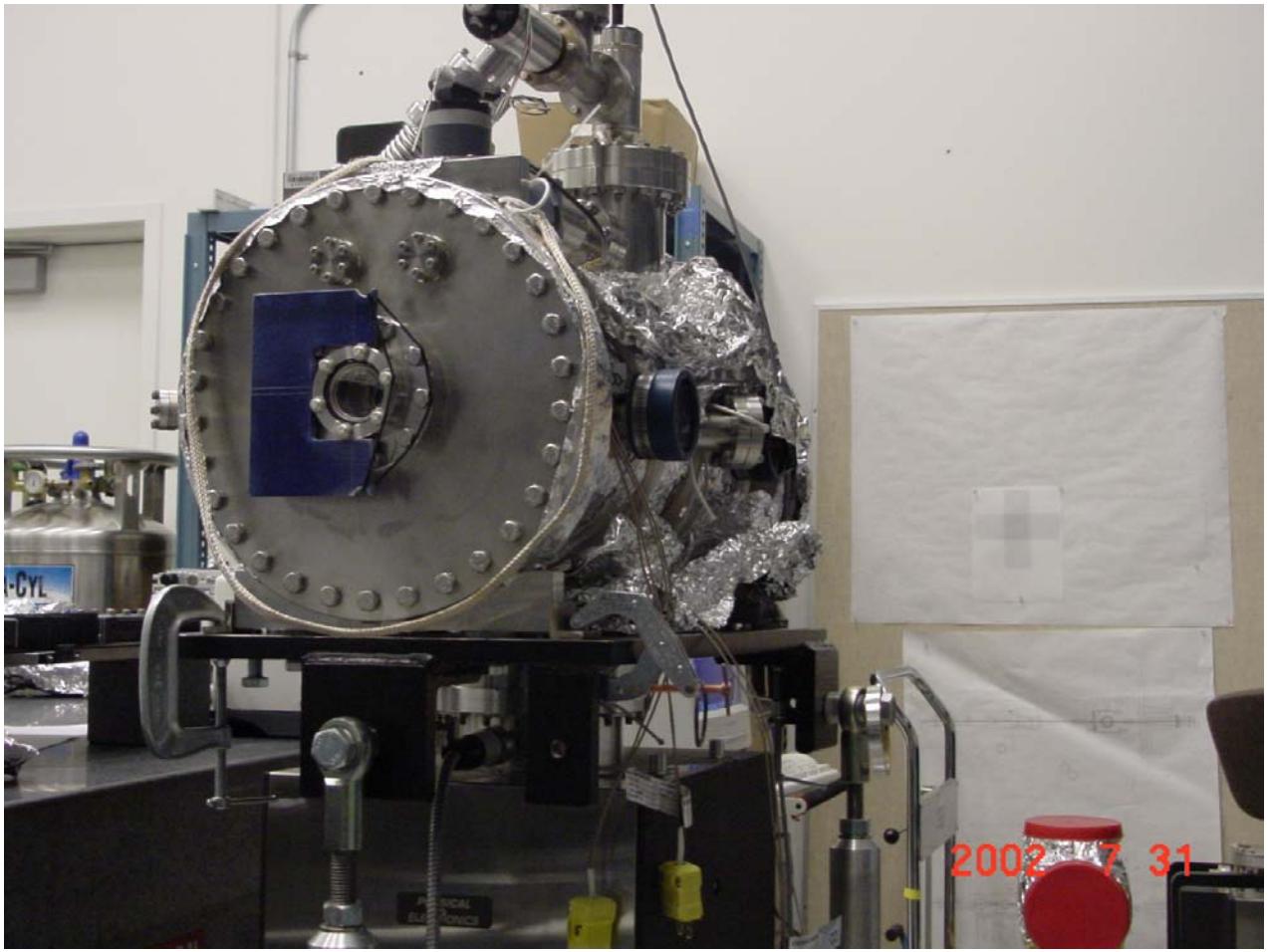
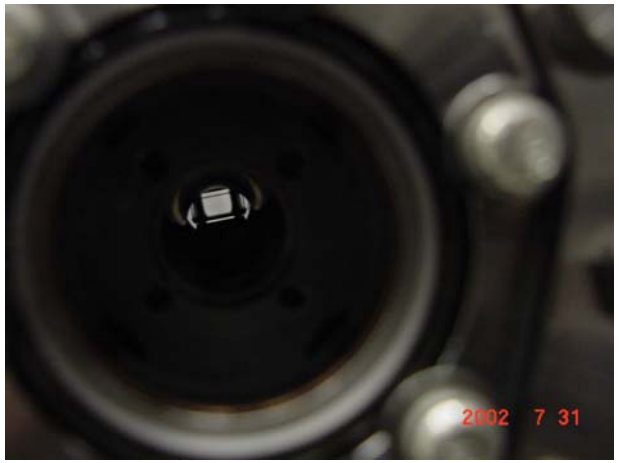


FIG. 4. (a) Magnetic dichroism spectra with various polarization, and (b) spin-resolved PES spectra with different degree of circular polarization with Fe/W(110) sample. Both spectra are normal emissions taken at photon energy 40 eV.

It



Thanks to Bruce, Glenn and John: we got it straightened up



17 July Ctd
Tightened N (rough)
−90 2.0 2.8 Δx 1.0 Δy 1.3 (90, 80)
0 2.0 1.5
90 1.0 1.5 Δx 1.2 Δy 1.0 (0 − 180)
180 0.8 2.5

18 July Left overnight.
180 1.0, 2.5 Δx 0.5 Δy 1.0 (0−180)
90 1.0, 2.0
0 1.5, 1.5 Δx 1.0 Δy 2.0 (90 − −90)
−90 2.0, 2.0
Second Reading
−90 2.0, 2.5
0 1.5, 1.5
90 1.0, 2.0
180 1.0 2.5
Exercised θ back and forth Several times
−90 2.0, 2.5
0 1.5, 1.5
90 1.0, 2.0
180 1.0, 2.5
Moved Hatu To 20° −
180 1.0, 2.5 Δx 1.0 Δy 0.3 θ 90−0
90 1.0, 2.0
0 1.5, 1.5 Δx 0.5 Δy 1.0 θ 0−180
−90 2.0, 2.3
Pumped down to HiVac −
−90 2.0, 2.5
0 1.5 1.5
90
180 1.0 2.0
1.0 2.5

Is the HTSC game over?

To: "Alexei Fedorov" <AVFedorov@lbl.gov>
Subject: Re: greetings
Date: Saturday, December 22, 2001 11:29 AM

If it is indeed true, it can be important. Maybe there are circulating currents of some sort that lead to a very tiny magnetic moment and violate time reversal symmetry. I can see at least Varma and Laughlin saying "I am right" (for different reasons).
How can you detect it through PES? I suppose you look for some signature in polarization.

From: "Peter Johnson" <pdj@bnl.gov>
To: "Alexei Fedorov" <AVFedorov@lbl.gov>
Subject: Re: Sr2RuO4
Date: Thursday, April 11, 2002 10:32 AM

Hi there,
Are you going to attempt the Campuzano expt? We may also do that.
However I am not sure that I believe it.
Peter

RAPID COMMUNICATIONS

PHYSICAL REVIEW B VOLUME 39, NUMBER 4 1 FEBRUARY 1989

Fermi-surface instabilities of a generalized two-dimensional Hubbard model

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(Received 20 July 1988)

Possible Fermi-surface-related instabilities in a Hubbard model, generalized so as to include finite-range and exchange interactions, are studied in the weak-coupling limit. In addition to the usual instabilities of superconducting, charge- or spin-density-wave type, two new types of instability are found. The first state is an orbital antiferromagnet, with currents circulating around each elementary plaquette. In the second phase, a *spin* current flows around the plaquettes. In both cases, there are low-temperature power laws in thermodynamic and transport properties. Two-dimensional fluctuation effects are shown to lead, for weak interactions, to a sharp crossover from a Fermi-liquid state to a regime governed by orientational fluctuations of the order parameter at fixed amplitude.